

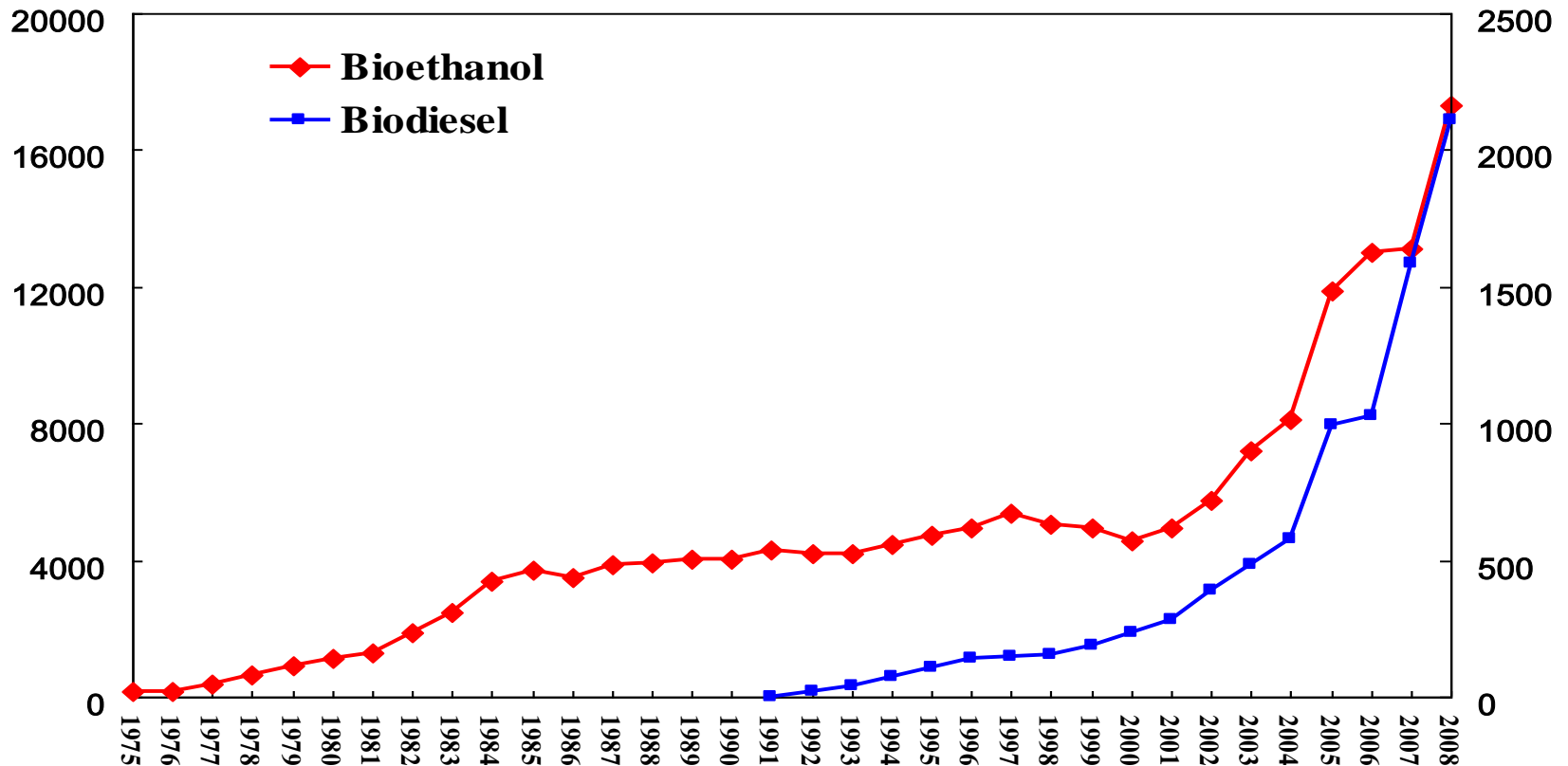
Progress on Global GTAP Modeling: Identifying Global Impact Pathways

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Development of Global Biofuel Production from 1975-2008 (million gallons)



Data source : F.O. Licht (2008)

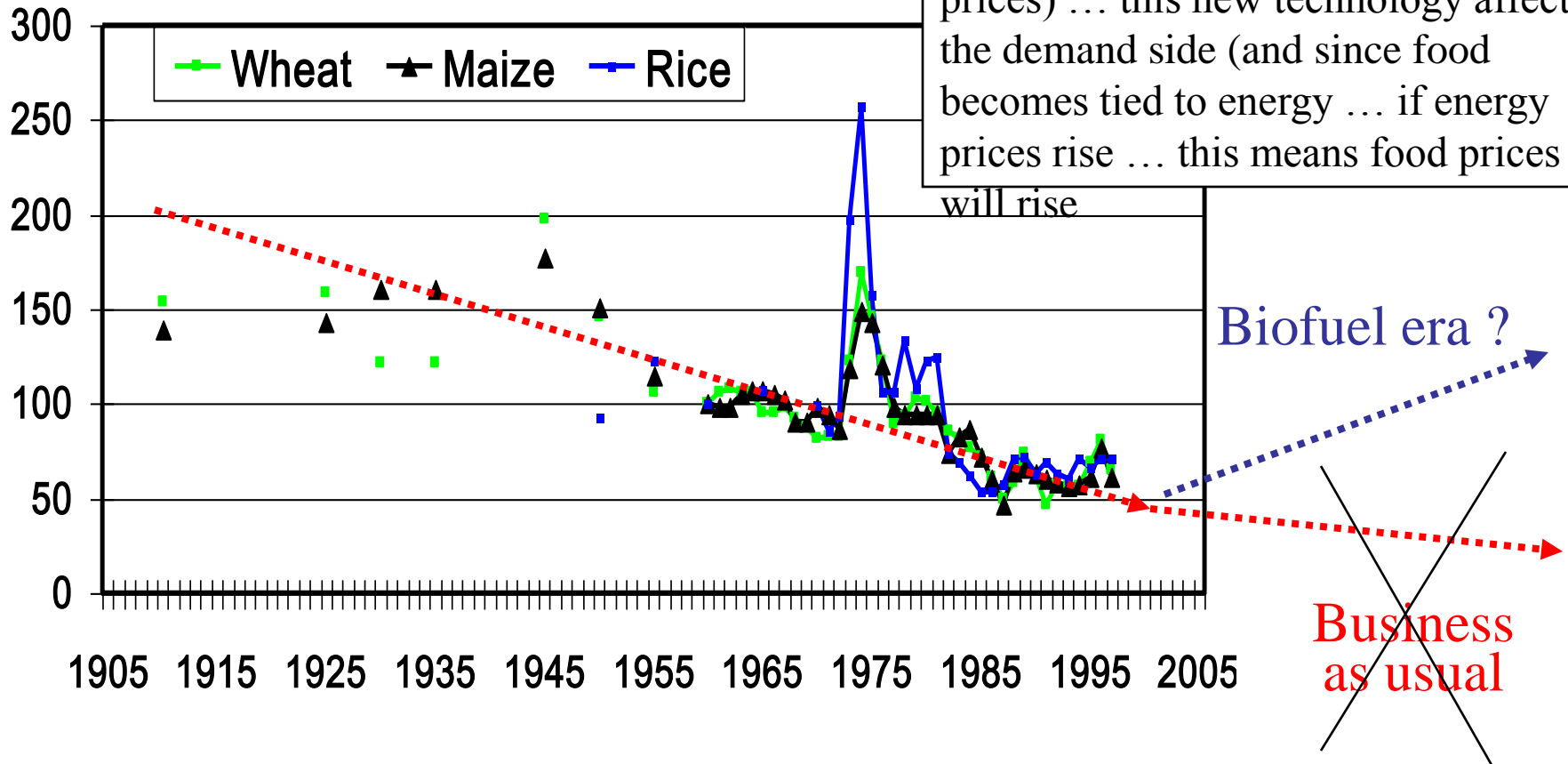
During 1990-2000, ethanol growth is **14%** in total

During 2001-2008, ethanol production rises by **251%** (average annual growth rate **20%**)

diesel production increase **649%** (average annual growth rate **33%**)

Biofuels is a fundamentally different technology ... it affects the demand side

Real cereal price index
(All prices = 100 in 1960)



It is possible – that we are in the middle of a fundamental watershed ... perhaps the greatest since the “invention” of genetics ... but, while genetics allowed for the rapid rise in supply (→ falling prices) ... this new technology affect the demand side (and since food becomes tied to energy ... if energy prices rise ... this means food prices

Is it sharp enough to cause the current rise in price?

So what are the exact global impacts?

- Goal of the rest of this talk is to try to chart the *Global Impact Pathways* of biofuels.
 - *Specific objective 1: create a modeling platform to analyze these questions*
 - *seek to understand what factors are particularly sensitive in determining the magnitude of impact (**energy price / substitution between gasoline and ethanol / DDG/ ability to expand land**)*
 - *Specific objective 2: examine impact of rise of biofuels on key countries in the world (price and trade flows), focus on poor areas of the world*
 - *Specific objective 3: understand the impact on poverty; water; and land use*

This is part I of Gates Foundation grant ... part II examines intensively the impact on consumers; producers; trade; and other factors in India; Senegal; Mozambique

Limitations

- Our results are still in early stages ... comments MORE THAN welcome ...
- No cellulosic biofuels ...
- TODAY: We are as much interested now in figuring out “what matters” ... and “where to put our energy in the coming months” ... as we are about “identifying the global impact pathways”

Organization of Rest of the Presentation

- Global Pathway:
 - The modeling approach (GTAP)
 - The data
 - Reference (baseline) and Scenarios
 - Sensitive scenarios (I)
 - energy price
 - substitution between gasoline and ethanol
 - Sensitive scenarios (II)
 - Considering DDG
 - Considering land expansion
 - Results

Identifying Global Impact Pathways

The modeling approach (GTAP)

Modified GTAP-E model

- Creating ethanol and diesel industry in the model
- More detail agricultural commodities
 - Separating maize from coarse grain
 - Separating soybean from oilseeds
- Adding the module to reflect the substitution between biofuel and gasoline
- Taking into the by products of Biofuel (DDGs)
- Including land expansion component

Special Features of Model

Highly detailed

- Sectors:
 - Rice; Wheat;
 - Maize; Sugar Cane; Sorghum; Tubers/Roots
 - Oilseeds
 - Other major crops (e.g., cotton)
- Biofuels subsector
 - Stand alone with own input-output tables
 - Ethanol / biodiesel are outputs
 - By products of biofuels (e.g., DDGs)
 - Multiple technologies
 - Maize / sugar cane
 - Developed country / developing countries

The data (1)

- **Input / output tables:**
 - all feedstock crops ...
 - biofuels production technology ...
 - By-products of biofuel
 - Potential land supply
- **Policies**
 - Targets / subsidies
 - Trade policies

The data (2)

- **Behavioral parameters**
 - **Substitution between maize and soybeans;**
 - **Substitution between ethanol and gasoline**
 - **Substitution between DDGs and feed grains**
 - **Land mobility among crops [e.g., can rice paddies be shifted into the production of maize ... and if so, at what degree of substitutability]**
 - **Mobility of primary factors between agricultural and industrial sectors [i.e., imperfect factor labor market, that is, it can happen, but not perfectly ...]**

Strategy for identifying global impact pathways:

Reference scenario

- Biofuels production in all countries in the world are kept at their 2006 level (in other words, we are simulating the effect of a world-wide ban of not allowing any expansion over what was already in place)

Two Key Alternative Scenarios

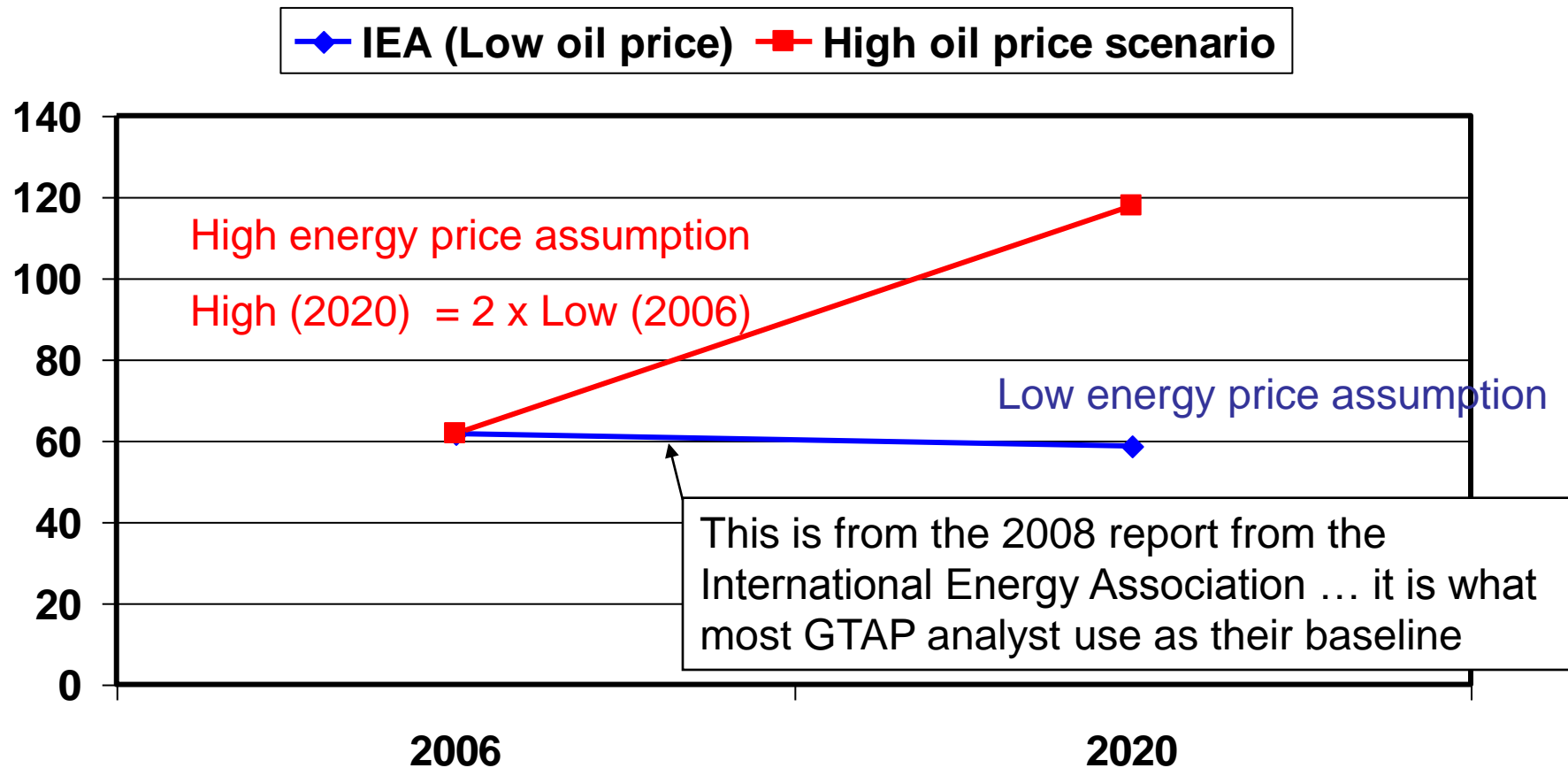
(Old ones, presented in previous meeting)

- **Market Scenario:** In the market scenario, governments do not intervene into the production decisions of biofuels producers ... Biofuels production is carried out purely on the basis of international energy prices
- **Policy Intervention Scenario:** In the policy intervention scenario, governments intervene into the production decisions of biofuels producers by offering subsidies (which are equivalent to those actually being considered as of 2008) ...

Targets of Biofuel Production in 2020 of Selected Countries

	2006	Target in 2020	Growth (%)
Ethanol (million tons)			
USA	15.9	117.8	641
EU	1.5	21	1300
Brazil	14.7	43.2	194
Diesel (million tons)			
USA	0.8	6.9	763
EU	4.9	46.4	847

Sensitive analysis on crude oil prices (US dollars per barrel) in 2006-2020



Sensitive analysis on elasticities of substitution between Gasoline and biofuel

- Low elasticity: 3

This (“3”) means that when the price of gasoline goes up, there is little impetus to substitute into ethanol

This is about the same level as used in the analyses by Hertel et al. (2-4) and the LEI Banse et al. (5)

- High elasticity: 20

This (“20”) means that when the price of gasoline goes up, there is a lot of impetus to substitute into ethanol [note: “100” is perfect substitution]

VERY VERY IMPORTANT ...

We also tried medium level (8 and 10) elasticities....

Analytical plan 1 (to help understand what really matters)

Low Energy Price Projections

High Energy Price Projections

Low Elast. Of
Substitution:
Gas and Ethanol

High Elast. Of
Substitution:
Gas and Ethanol

Low Elast. Of
Substitution:
Gas and Ethanol

High Elast. Of
Substitution:
Gas and Ethanol

**Reference
Scenario**

**Market
Scenario**

**Policy
Intervention
Scenario**

Notes:

Low Energy Price from IEA;

High Energy Price = (2 x Low Energy Price)

Low Elast. of Sub., Gas and Ethanol = 3; High Elasticity = 20

Analytical plan 2 (to help understand what really matters)

Low Energy Price Projections

High Energy Price Projections

Low Elast. Of
Substitution:
Gas and Ethanol

High Elast. Of
Substitution:
Gas and Ethanol

Low Elast. Of
Substitution:
Gas and Ethanol

High Elast. Of
Substitution:
Gas and Ethanol

**Reference
Scenario**

**Market
Scenario**

-- DDG
-- Land

**Policy
Intervention
Scenario**

-- DDG

Notes:

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Analytical plan 2

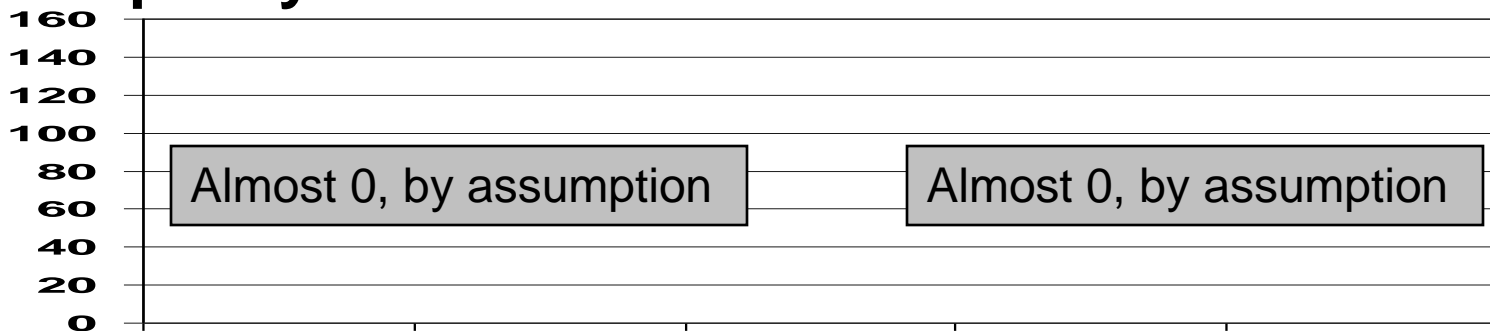
- **On the top of LL-policy intervention and HH-marketing scenarios under analytical plan 1, we consider:**
 - **By-products of biofuels**
 - **Potential land expansion**

(we will present major assumptions on biofuel by-products and land expansion in later part of this presentation)

Scenario Results on the Analytical Plan 1

Ethanol production (% change) in 2020 over 2006 under policy intervention scenario in USA

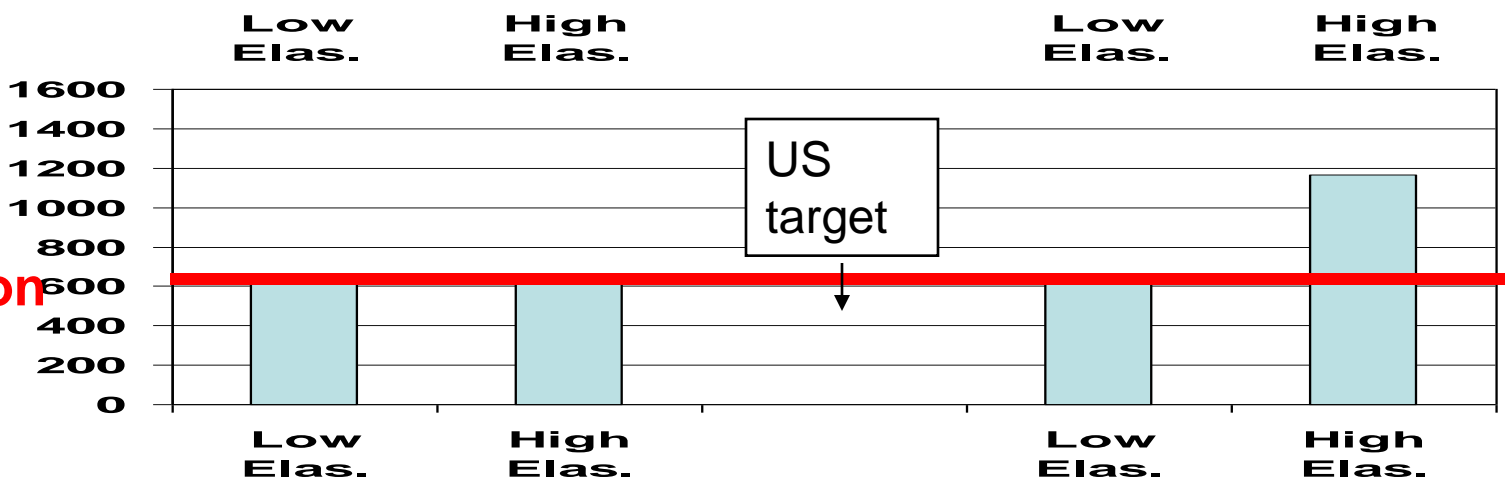
Reference Scenario



Market Scenario



Policy Intervention



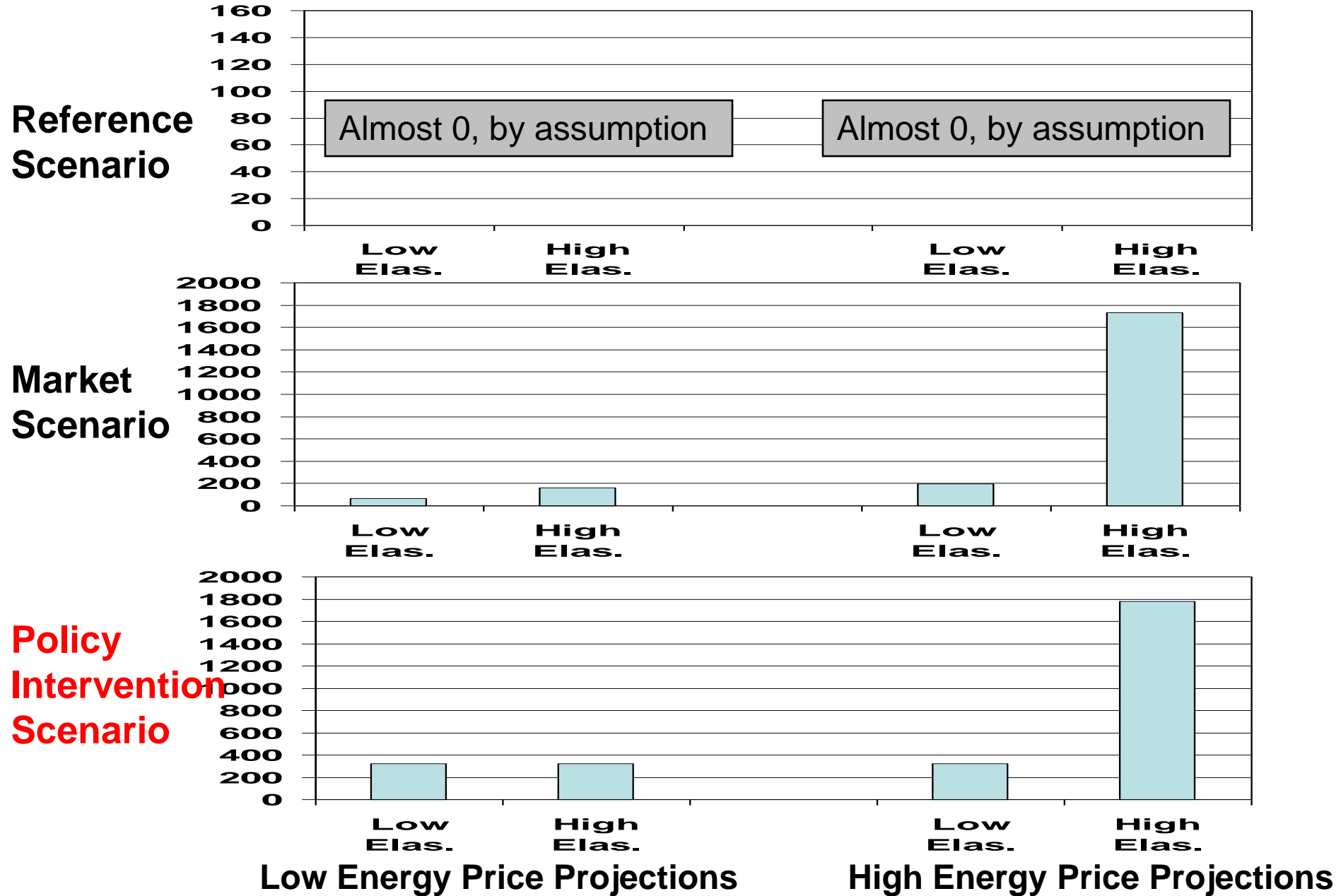
Low Energy Price Projections

High Energy Price Projections

Observations on US biofuels production

- Production at low energy prices / no policy intervention: nearly 0
- There is some biofuels produced at high energy prices ... the substitution of ethanol and gasoline REALLY MATTERS ...
- US policy really matters (determines biofuels production ... except in a world with high energy prices / and a fleet of cars in which ethanol is a close substitute for gasoline) ...
- High price / high substitutability: Only energy prices matter ... biofuels is NOT being driven by government policy ...

Diesel production (%) in 2020 over 2006 under policy intervention scenario in EU27



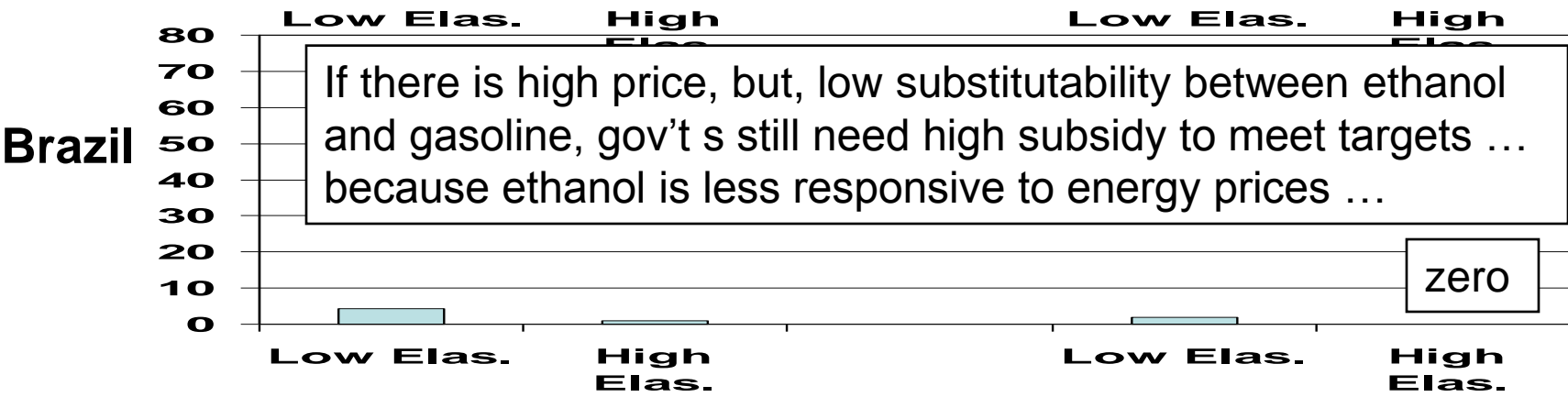
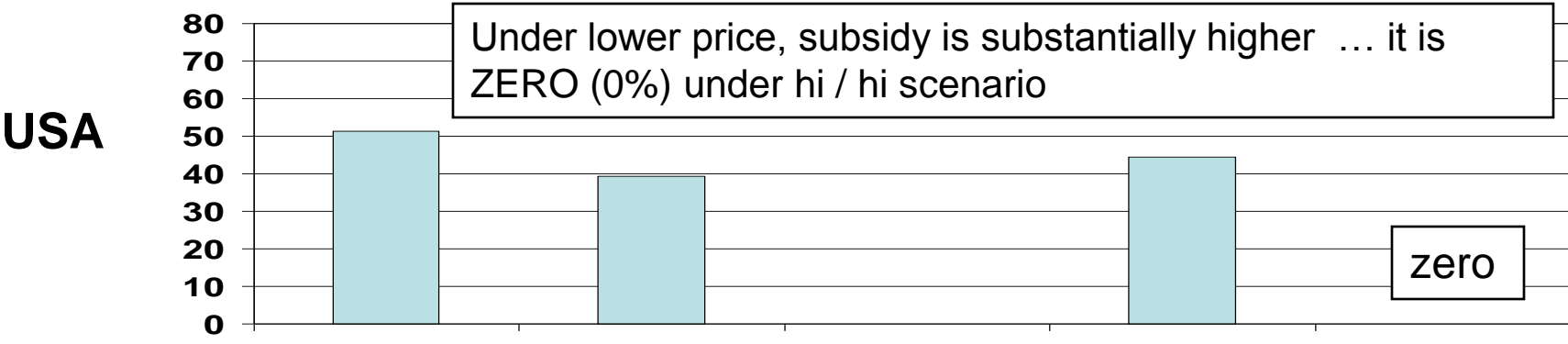
Maize prices, production and exports in US under assumptions of oil price and elas. of substitution (comparing to reference,2020)

	Market		Policy intervention	
	Low Price	High Price	Low Price	High Price
Price				
High subst.	1.6	112.5	42.7	112.5
Low subst.	1.6	8.8	42.7	43.9
Production				
High subst.	1.1	88.7	54.2	88.7
Low subst.	2.1	10.2	54.3	52.9
Export				
High subst.	-1.5	-63.5	-42.8	-63.5
Low subst.	-2.3	-14.3	-42.8	-44.2

Rapeseeds prices, production and exports in EU under various assumptions of oil price and elas. of substitution (comparing to reference,2020)

	Market		Policy intervention	
	Low Price	High Price	Low Price	High Price
Price				
High subst.	6.5	106.7	41.2	106.7
Low subst.	2.9	9.4	41.2	40.8
Output				
High subst.	17.2	185.6	118.7	185.6
Low subst.	11	31.2	118.7	118.9
Export				
High subst.	-6.1	-29.1	-17	-29.1
Low subst.	-2.8	-13.1	-16.9	-20

Government subsidy (billion US\$) in 2020 under policy intervention scenario



Low Energy Price Projections

High Energy Price Projections

Generalizations – impacts of biofuels on key/developed country that are major agricultural producers

- Biofuels matter ...
 - Biofuels policy matters (quite a bit) ... [in a lo / lo world, biofuels would not expand without policy]
 - **But**, if ethanol and gasoline are highly substitutes, high energy prices will drive biofuels development ...
 - Price of substitutes (soybeans,wheat...) also rise ...
- Methodology side: *substitutability* is key. Impacts will be reduced by about one third if we change substitution elasticities from 20 to 10...

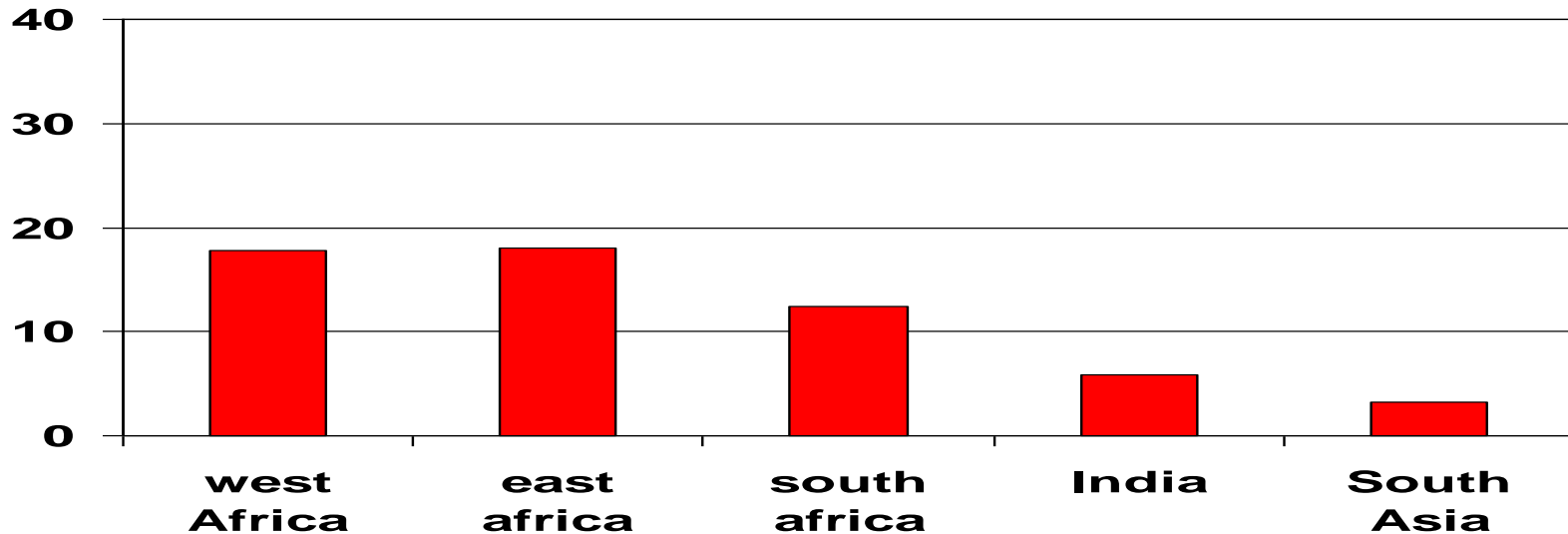
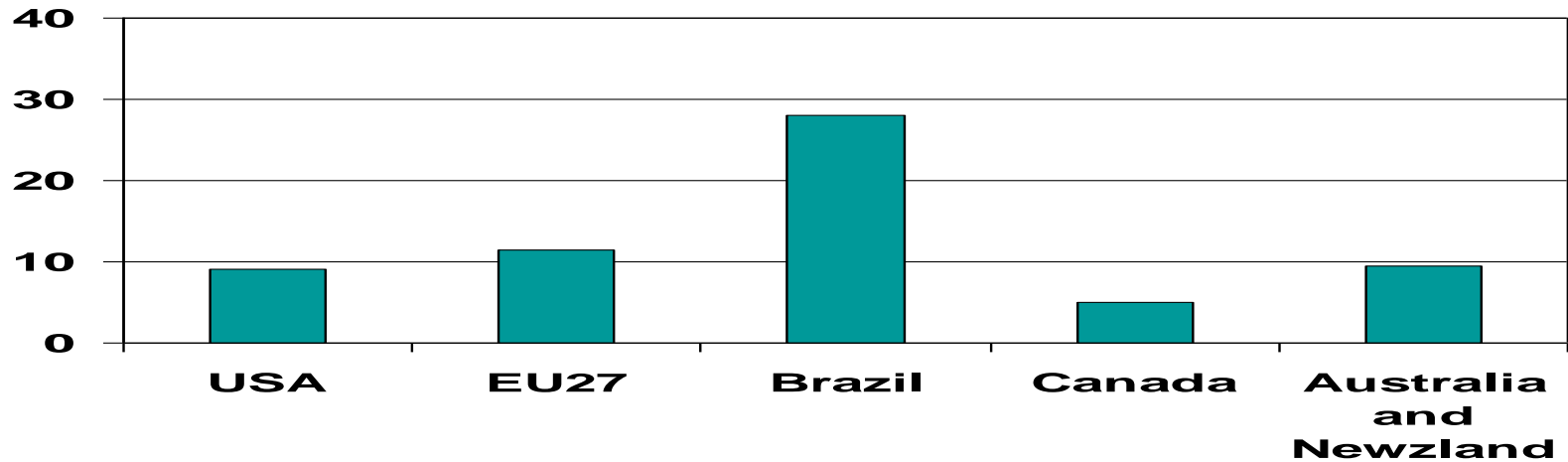
Biofuels and the Poor

- East Africa
- West Africa
- South Africa
- India
- Rest of South Asia

Impacts on the price, production, export and self-sufficiency of selected developing countries in HH scenarios (comparing to reference, 2020)

	East Africa	West Africa	South Africa	India	Rest of South Asia
Maize					
Price	45.4	38.5	37	58.1	24.5
Production	30.3	21.9	15.2	61.4	15.6
Export	2631.2	6224.3	613.9	437.1	9721.4
Self-sufficiency	30	21	15	77	12
Wheat					
Price	26.4	30.3	33.8	29.6	19.4
Production	2.8	3.7	13.2	3.5	7.3
Export	52	56.6	42.9	20.3	146.1
Self-sufficiency	2	2	13	9	5

Impact of rise of biofuels on Farmer's wage in 2020 under HH (comparing to RS, %)



Generalizations: Biofuels and the Poor

- If energy prices stay high ...
But, even under policy scenario (with lower energy prices),
Prices are going to rise in developing countries
- Good news for producers ... bad news for consumers ... but, of course, we know from the Green Revolution story, it is more complicated (part of those complications looked at next section / detailed analysis in part II—2009 of Biofuels and the Poor project) ...
- For agriculture, this could be a **HUGE opportunity**

Analytical Plan 2:

(1) Modeling on By-products

Analytical plan 2a

Low Energy Price Projections

Low Elast. Of
Substitution:
Gas and Ethanol

High Elast. Of
Substitution:
Gas and Ethanol

High Energy Price Projections

Low Elast. Of
Substitution:
Gas and Ethanol

High Elast. Of
Substitution:
Gas and Ethanol

**Reference
Scenario**

**Market
Scenario**

**-- DDG
(B)**

**Policy
Intervention
Scenario**

**-- DDG
(A)**

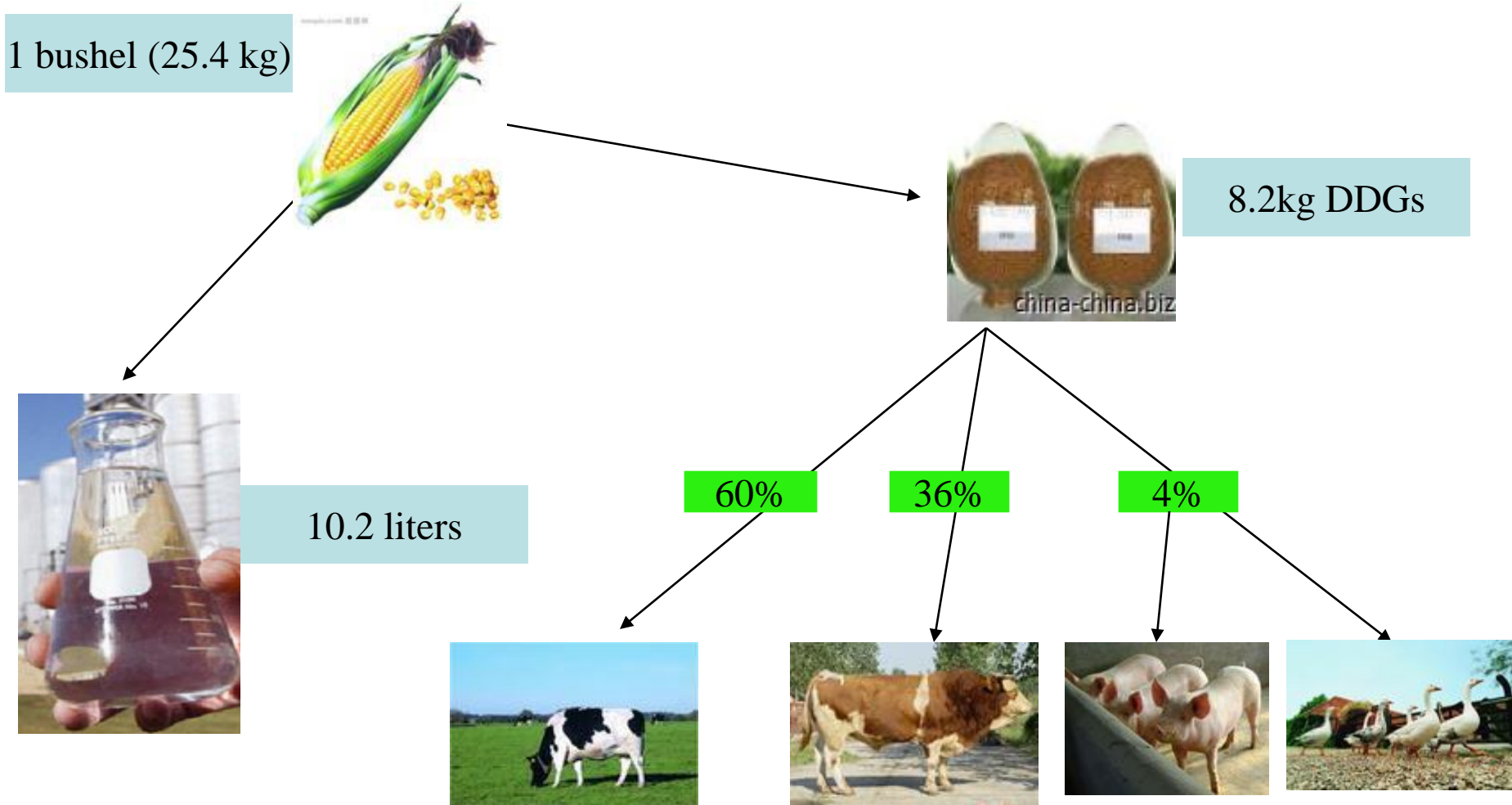
Notes:

Low Energy Price from IEA;

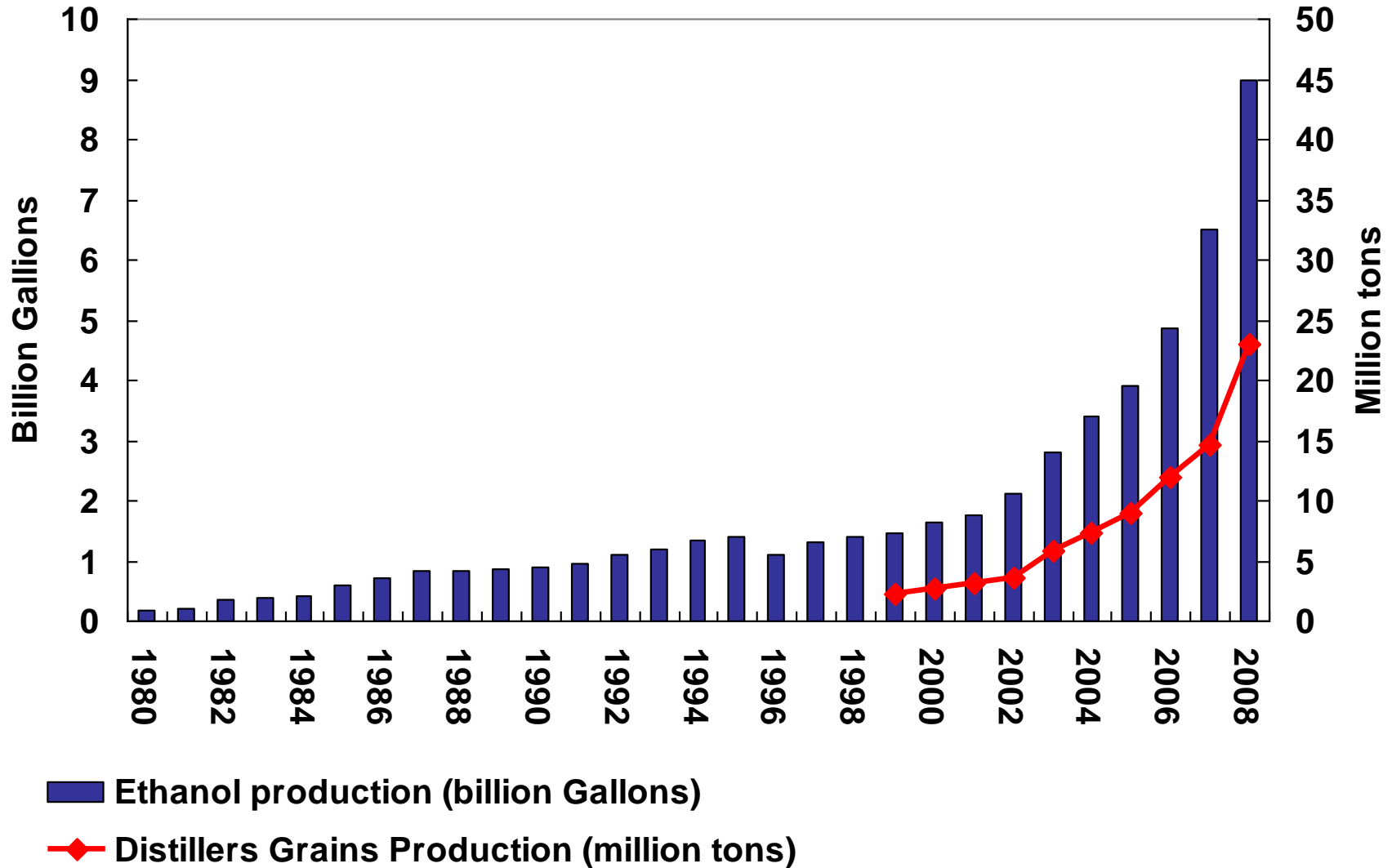
High Energy Price = (2 x Low Energy Price)

Low Elast. of Sub., Gas and Ethanol = 3; High Elasticity = 20

Output of ethanol productions and distributions of DDGs usage in USA

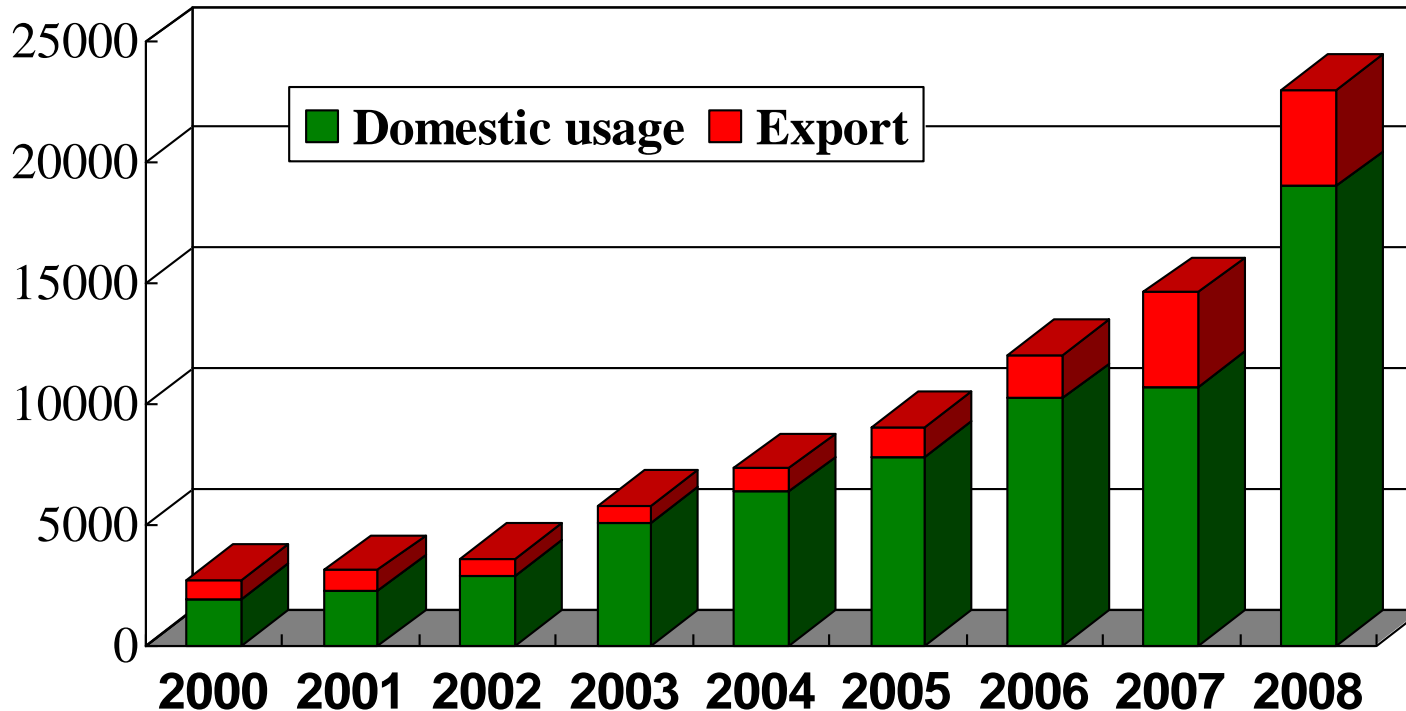


Historical Ethanol and DDGs production in US



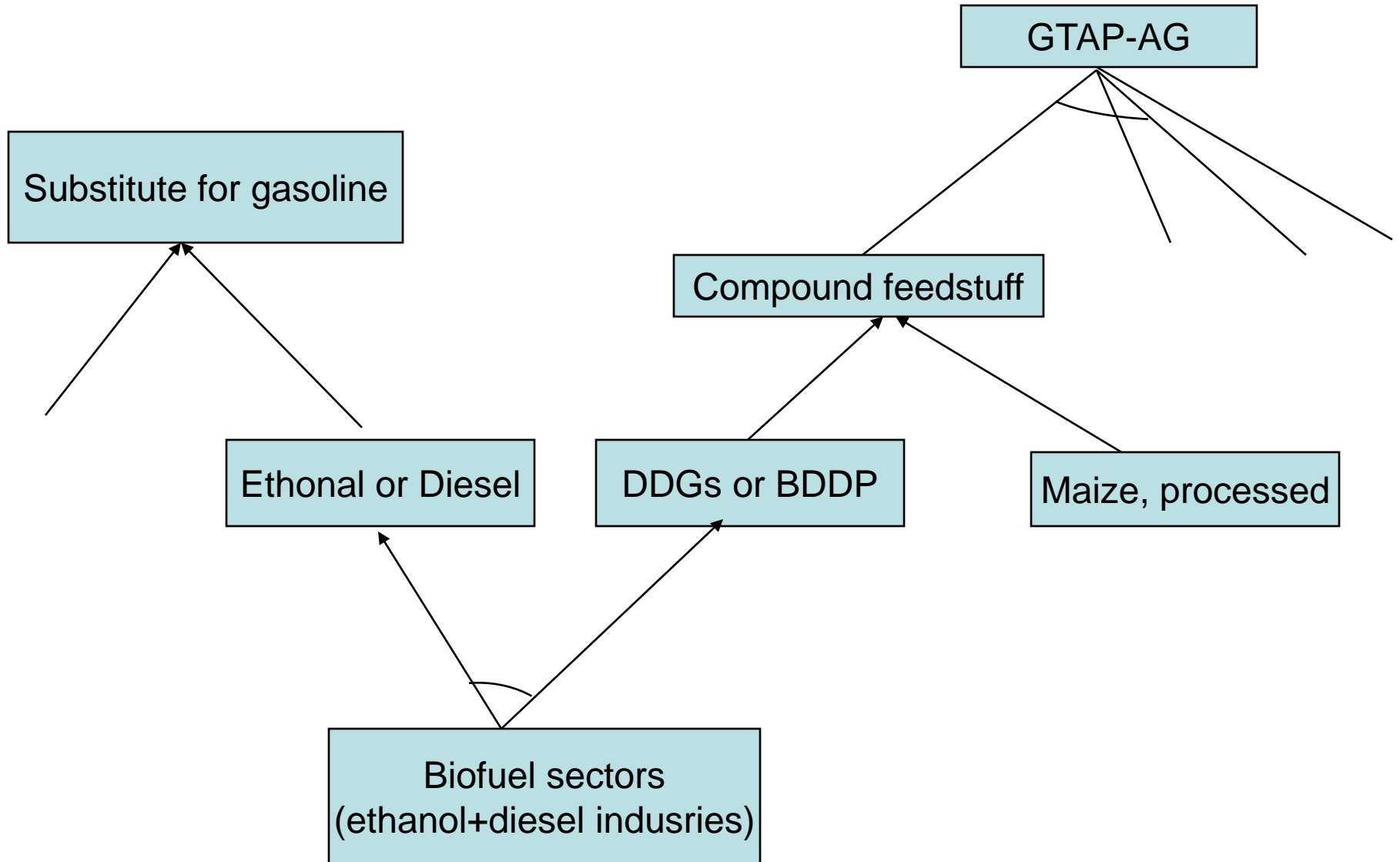
Data source: RFA(2009)

Usage of DDGs in USA



DDGs production had increased from **2.7** million tons in 2000 to **23** million tons in 2008, average annual growth rate about **30.7%**. Domestic usage increase more faster at annual growth of **44.5%**. It has arrived at **19** millions in 2008.

New Modeling structure for Biofuel By-products



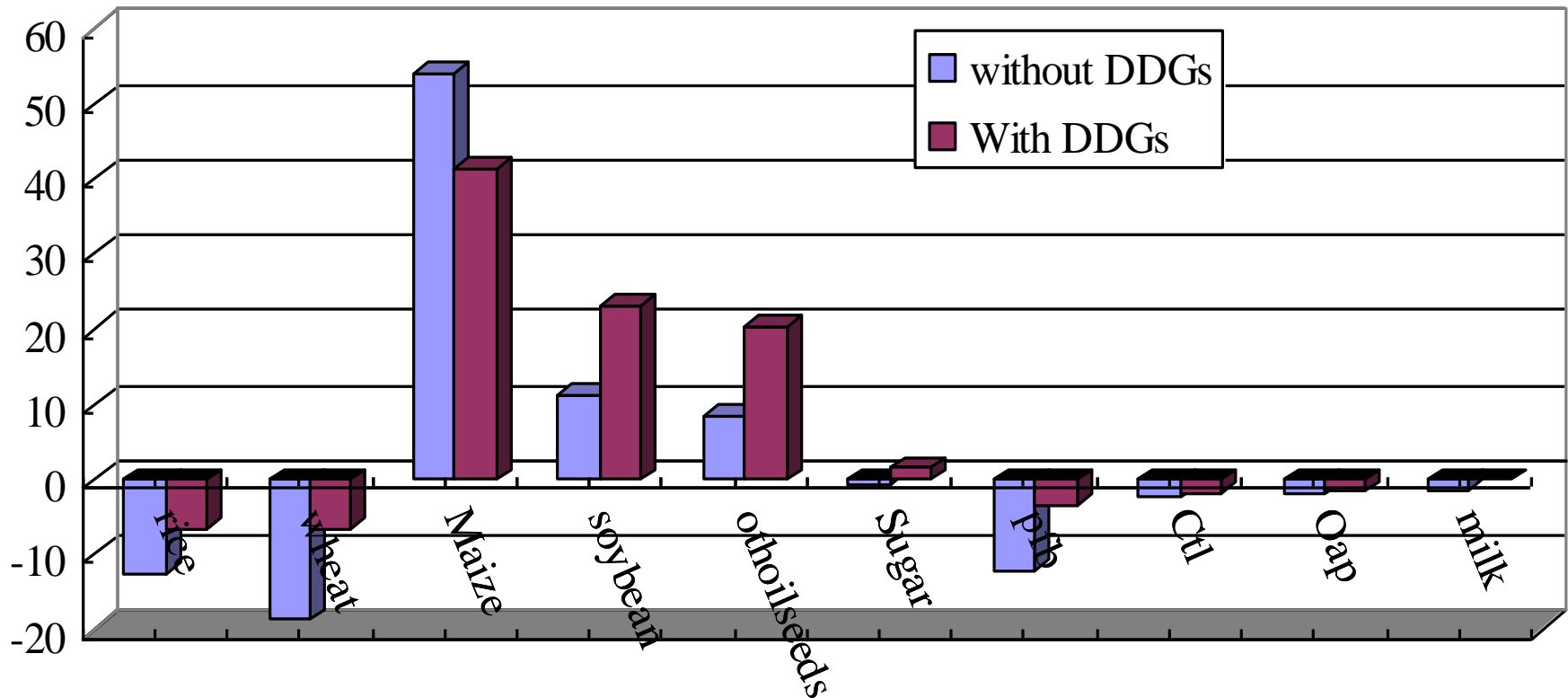
Further improvements on modeling by-products of biofuels

- More efforts need to refine the model and database on by-products study...
 - New production function of multi-inputs and multi-outputs. Ratio of output between ethanol vs. DDGs and Diesel vs. BDDP is the key.
 - Substitution between by-products and other feedstuffs (maize, processed feed etc.) and the degree of substitution.
 - Trade flows of By-products (DDGs+BDDP)

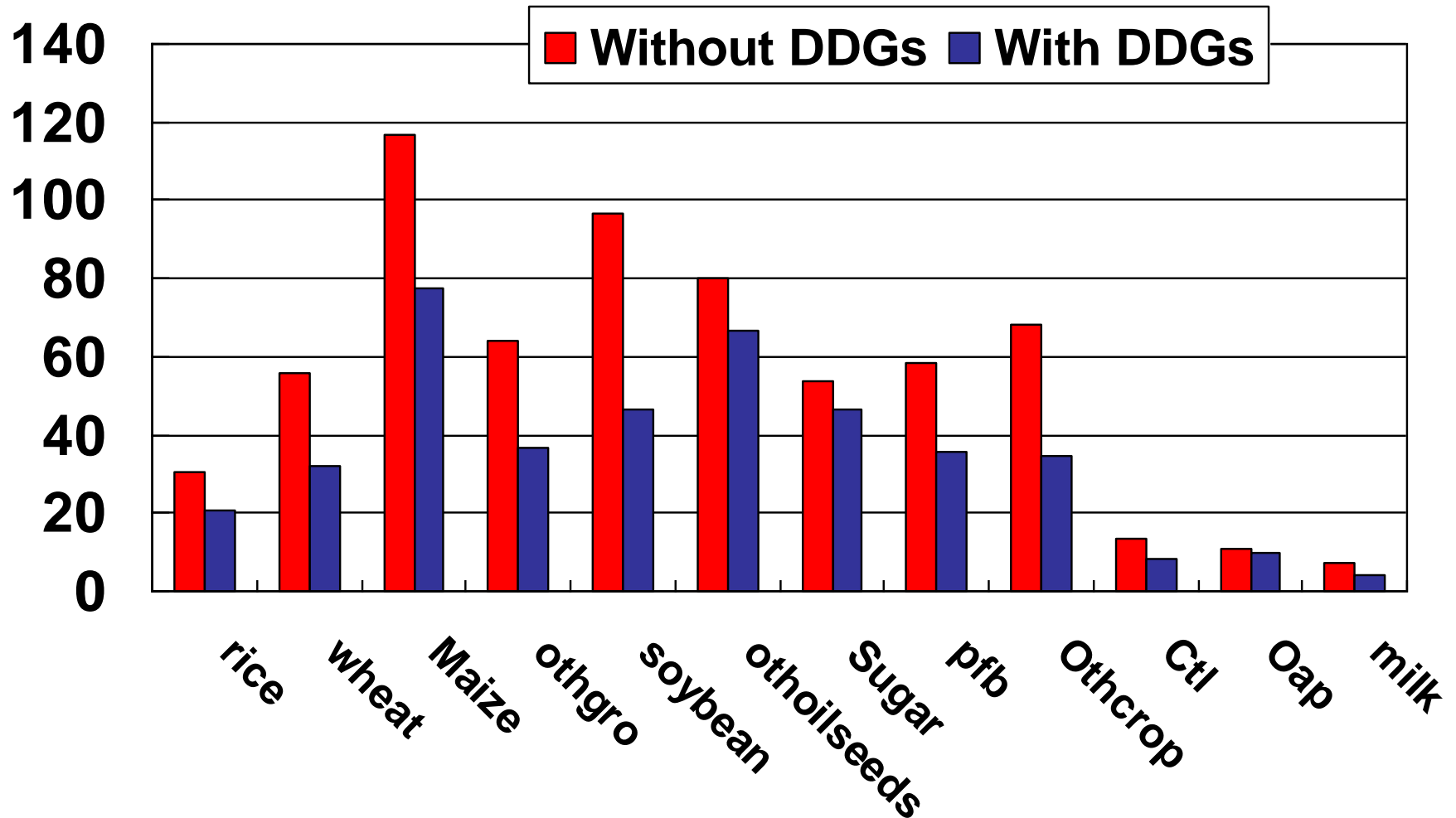
Price Impacts of realizing biofuel targets of EU, USA and Brazil in 2020 under DDG-(A), comparing to baseline (%)

	Results with Byproducts			Results without Byproducts		
	USA	Eu27	Brazil	USA	Eu27	Brazil
rice	3.8	1.6	5.8	8.9	4.4	9.8
wheat	5.1	3.6	5.4	15.2	12.3	11.5
Maize	26.4	16.9	13.4	42.7	21.2	16.4
soybean	15.2	5.6	8.0	25.5	13.9	14.6
othoilseeds	14.1	22.2	16.6	20.4	41.2	23.2
Sugar	11.2	5.6	17.3	17.0	10.0	20.1
Cattle	2.5	1.8	5.1	3.7	3.0	6.8
Pork	2.2	1.8	4.7	2.9	3.2	6.7
milk	0.4	-0.1	3.1	1.4	0.2	2.8

Production impacts of realizing biofuel targets in US under DDG-(A), comparing to baseline (% ,2020)



Price change in US under the H-H scenarios with and without by-products (DDG-B)



Analytical Plan 2:

(1) Modeling on By-products

(2) Potential land expansion

Analytical plan 2a

Low Energy Price Projections

Low Elast. Of
Substitution:
Gas and Ethanol

High Elast. Of
Substitution:
Gas and Ethanol

High Energy Price Projections

Low Elast. Of
Substitution:
Gas and Ethanol

High Elast. Of
Substitution:
Gas and Ethanol

**Reference
Scenario**

**Market
Scenario**

-- DDG (B)
-- LAND

**Policy
Intervention
Scenario**

Notes:

Low Energy Price from IEA;

High Energy Price = (2 x Low Energy Price)

Low Elast. of Sub., Gas and Ethanol = 3; High Elasticity = 20

Two general methods are used...

1. All kinds of lands are included. So, the cultivated lands just come from their land types.
 - In GTAP model, the value term of crops land, pastureland and forestry is **74: 22: 4**, lower estimation of certain lands important in our research...
2. Directly give exogenous shocks to the total land supply.
 - **all land supply will increase...** as very low substitution between crops with others ...

- **Our strategy:**

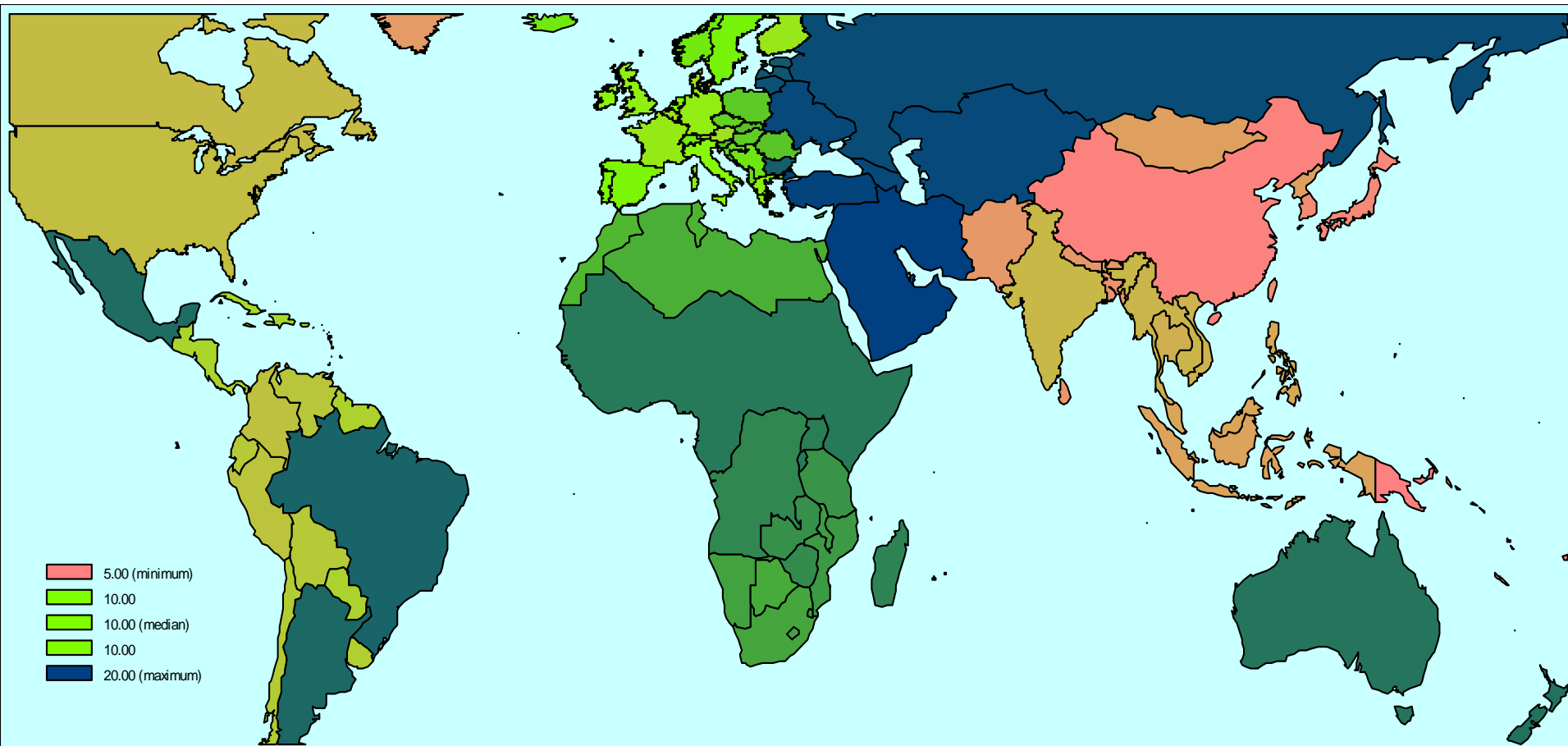
- shock the cultivated land, pastureland and forestry separately...

- More clearly, and also consistent to the real information

- However, more information needs...

- In the model, there are three types of land... We **isolates the model endogenous adjustments, with exogenous shocks based on extra information...**

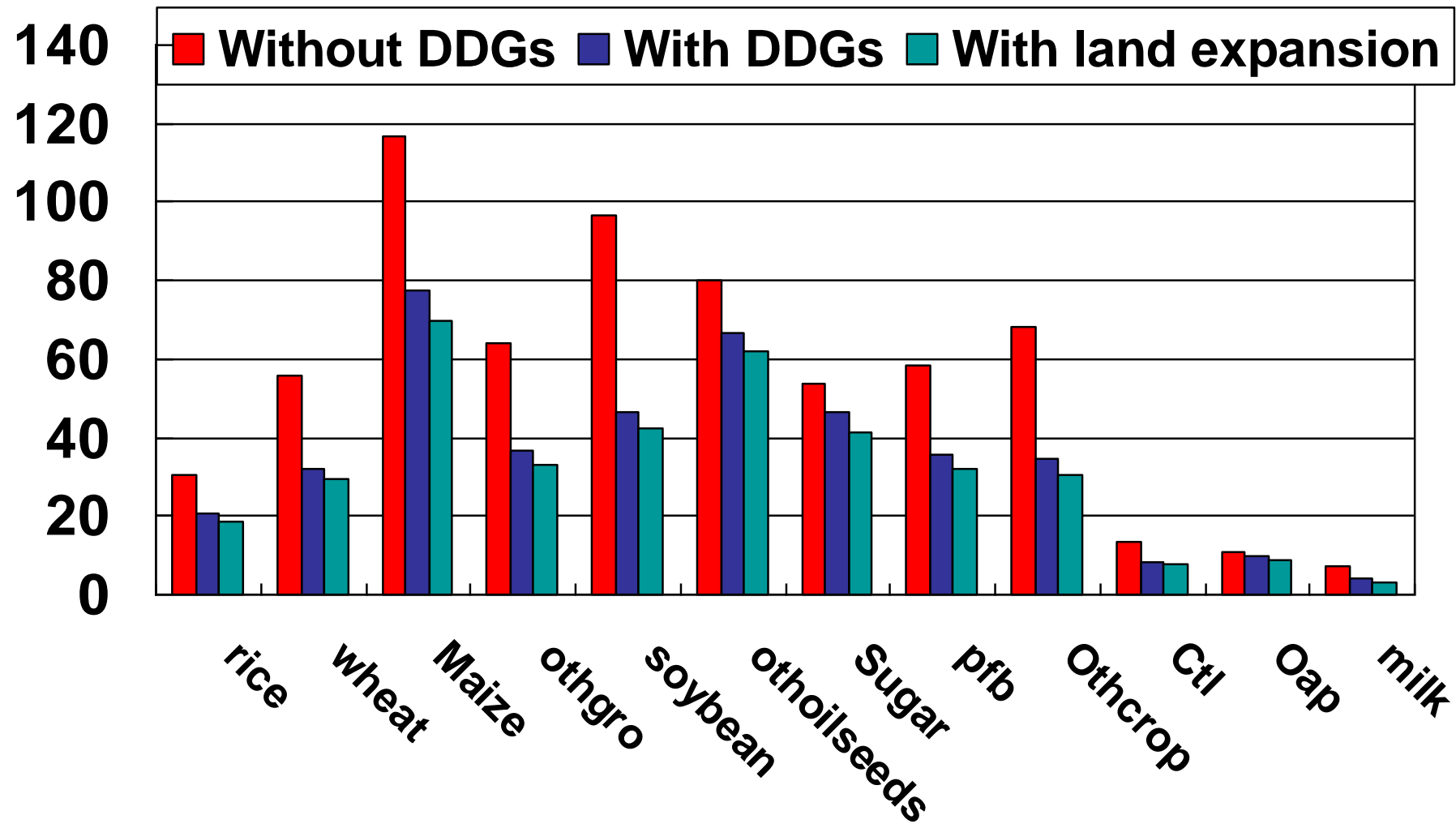
Assumptions on increase of crops land under H-H scenario, relative to baseline (%)



Preliminary results with increasing land supply caused by Biofuel developments

- Target:
based on the individual countries land supply situation, the potential land supply are estimated. With considering this information, we try to understand the lowest (most optimistic) price effects...
- H-H scenario with by products + **Increasing land supply**

Price change under the H-H scenarios without DDGs, with by-products (DDG-B) and further considering land expansion (land)



Remarks on DDGs and Land Expansion

- **DDGs and Land expansion will reduce the extent of rising agricultural prices.**
 - **According to our analysis, the rising price will drop about one third as considering by-products of biofuels.**
 - **It would be further reduced by about 10%-15% under our assumptions of expansion of land.**

In sum, even taking the impacts of both DDGs and land expansion, the impacts of biofuels on agricultural price will still be large under H-H scenario. Further consider technology innovations may help to reduce the impact of biofuel on food sector...

Up to know...

- Analytic platform has been preliminarily constructed...
 - More detailed information on Data...
 - Further improvements and estimations on some key parameters...
 - Refine the model...
 - Robust test of model system.
 - ...
- **Still need a lot input from you, that is why we are here...**

Thank You

Comments welcome